EXPERIMENT TO DETECT MARTIAN PERMAFROST BASE/GROUND WATER AND BIOGENIC METHANE FROM AN ORBITER AND/OR LANDERS ON MARS

Final Report

JPL Task 1007

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A. OBJECTIVES

I have proposed an experiment to detect subsurface clathrate hydrate by determining local curvature in the melting isotherm (by EM sounding). The task was to investigate the feasibility of my experiment for Mars.

B. PROGRESS AND RESULTS

Partial quantitative analysis for the feasibility of determining a curvature in the Martian ground ice/ground water interface and, therefore, the existence of possible subpermafrost methane clathrate hydrate was performed. For the regime of EM sounding, frequencies less than 1 MHz are recommended as a result of this study.

It was understood that my approach is important in light of the interpretation of continuous permafrost and clathrates as a "lid" for possible subpermafrost reduced biogenic gases. Hence, surface detection of these gases is not possible in spite of their presence at depth. Also, a search was performed for evidence linking Martian geomorphological features and ground water.

As a result of my investigation, the uncertainty in determining the position of ground ice base (melting isotherm) in the Martian subsurface as a function of latitude, using new Mars Global Surveyor Thermal Emission Spectrometer brightness temperature data, was assessed. I have concluded that the accuracy of the annual average Martian surface temperature estimates, prior to the measurement of the Martian surface brightness temperature by the MGS TES instrument, was better than the accuracy to which the other parameters (thermal conductivity and the Martian internal heat flow due to radioactive decay in the core) required to calculate the position of the zero-degree isotherm are currently known.

Secondly, as a result of my investigation, I have concluded that it is better to use the lower-frequency inductive regime rather then the radar regime to obtain an echo from the ground ice/ground water interface globally.

Based on my studies, I make the following recommendations for accessing the Martian subsurface: to drill in the chaotic terrain, which is at the source of Martian outflow channels, for the reason of possible subsurface methane clathrate hydrate deposits. I recommend drilling in the basins not near the equator (where the melting isotherm comes closest to the surface), but in the

mid-latitudes, because the melting isotherm might overlap with the desiccation front, and they have the opposite curvatures.

Thirdly, permafrost features such as thermokarst, polygonal terrain, pingos and rampart craters are very important to determine future landing/drilling sites. They can be identified from the Mars Global Surveyor Mars Orbiter Camera images, which have about 1 m resolution.

Also, I have investigated the possible depletion of the Mars ground water reservoir during the past 3 Ga. From my numerical analyses, I conclude that the best drilling sites to search for Martian ground water would be on the potential intersection of the desiccation front and the permafrost base. From my current investigation, and utilizing terrestrial analogs, I recommend narrowing these "optimal" areas by using the surface manifestation of permafrost/near-surface ground water: pingos, thermokarst, rampart craters. As a result of my investigation, I recommend a concrete region for future drilling missions on Mars: Utopia Planitia, and preferentially its southern part.

To perform this research, I have used the Mars Topographic Globe (constructed using MOLA data) and the book by E. D. Sloan (1998). Despite a previously common concept of a geothermal melting origin of potential Martian subpolar water, I have proven the opposite origin using the MGS MOLA data. I have also investigated the mechanism of sub-ice lake survival on Mars.

C. SIGNIFICANCE OF RESULTS

SHARAD radar on MRO operates in the range of frequencies 15 - 25 MHz, which are higher frequencies than the Mars Express (2003) MARSIS frequencies of 1 - 5 MHz, and thus the penetration depth of SHARAD will be less. The effective sounding depth for MARSIS is about 2 km. As a result of my investigation, for my method, which combines thermoprospecting and electrical prospecting on Mars, I suggest using the inductive rather than the radar regime for subsurface sounding. As a result of this research: I have also co-authored 2 chapters in the book "The Future of Solar System Exploration," one of them on terrestrial analogs for Mars.

My two New Technology Reports were accepted by *NASA Tech Briefs* with the subsequent awards to me as the Class 1 Innovator. I have submitted a proposal "Comparative Studies of Martian Ices, Water, Clathrates and Their Terrestrial Analogs" as a PI to NASA's Mars Fundamental Research program. I have submitted a 2nd proposal, "Mapping Thermal Distribution and Ground Ice Conditions at the Near-surface Martian Landforms," as a Co-I to NASA's Geology and Geophysics program. I have recently reviewed an article about Mars at the request of the *Journal of Geophysical Research.* Additionally, I have co-authored 2 abstracts on the exploration of Mars (to AGU and DPS).

D. FINANCIAL STATUS

The total funding for this task was $25,000, of which $23,700 was expended.

E. PERSONNEL

No other personnel were involved.

F. PUBLICATIONS

1. N. S. Duxbury and V. Romanovsky, "Methane Clathrate Hydrate Prospecting," *NASA Tech. Briefs Journal*, NTR-30257, (in press) (2002).

2. N. S. Duxbury and V. E. Romanovsky, "Permanent Sequestration of Emitted Gases in the Form of Clathrate Hydrates," NASA Tech. Briefs Journal, NTR 30256 (in press) (2002).

3. T. G.Farr and co-authors, including N. Duxbury, "Terrestrial Analogs to Mars," *The Future of Solar System Exploration*, 2003-2013, National Academy of Sciences (NAS), Ed. M. Sykes, (2002).

4. N. G. Barlow, T. Farr, V. R. Baker, N. Bridges, F. Carsey, N. Duxbury et al., "Community Decadal Panel for Terrestrial Analogs to Mars," abstr., September 2002, Birmingham, 33 DPS Meeting.

5. T. Farr and co-authors, including N. Duxbury, "Terrestrial Analogs to Mars: NRC Community Panel Decadal Report," December 2002, AGU conference, San Francisco.

G. REFERENCES

[1] E. Dendy Sloan, *Clathrates Hydrates of Natural Gases* (1998),